# PART I - ADMINISTRATIVE

## Section 1. General administrative information

**Title of project**

Path - Uw Technical Support

**BPA project number:** 9700200
**Contract renewal date (mm/yyyy):** 10/1999 ☐ **Multiple actions?**

**Business name of agency, institution or organization requesting funding**
University of Washington

**Business acronym (if appropriate)** UW

**Proposal contact person or principal investigator:**


| | |
|---|---|
| **Name** | James J. Anderson |
| **Mailing Address** | 1325 - 4th Ave., Suite 1820 |
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**NPPC Program Measure Number(s) which this project addresses**
3.2A, 3.2F, 4.2A, 4.3, 7.1E

**FWS/NMFS Biological Opinion Number(s) which this project addresses**
NMFS Hydrosystem BO RPA 13; RPA A17

**Other planning document references**
NMFS Recovery Plan Task 0.3.b and 2.11.b

**Short description**
Test hypotheses underlying key salmon recovery management decisions, develop decision analyses to evaluate alternative management strategies, and assist in designing research monitoring and adaptive mangement experiments.

**Target species**
Chinook and steelhead

## Section 2. Sorting and evaluation

**Subbasin**

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***Evaluation Process Sort***

| CBFWA caucus | Special evaluation process | ISRP project type |
|---|---|---|
| Mark one or more caucus | If your project fits either of these processes, mark one or both | Mark one or more categories |
| ☒ Anadromous fish<br>☐ Resident fish<br>☐ Wildlife | ☐ Multi-year (milestone-based evaluation)<br>☐ Watershed project evaluation | ☐ Watershed councils/model watersheds<br>☒ Information dissemination<br>☐ Operation & maintenance<br>☐ New construction<br>☒ Research & monitoring<br>☐ Implementation & management<br>☐ Wildlife habitat acquisitions |

## Section 3. Relationships to other Bonneville projects

***Umbrella / sub-proposal relationships.*** List umbrella project first.

| Project # | Project title/description |
|---|---|
| 20537 | Bonneville Power Administration Non-Discretionary Projects |
| 9700200 | PATH - UW Technical Support |
| | |
| | |

***Other dependent or critically-related projects***

| Project # | Project title/description | Nature of relationship |
|---|---|---|
| 9601700 | Technical support for PATH-Chapman Consulting | Path scientific report |
| 9600600 | Path-Facilitation, Technical Assistance, and Peer Review | Path scientific report |
| 9600800 | Path-Participation by State & Tribal Agencies | Path scientific report |
| 90898 | Technical support for PATH-JJA | Path scientific report |
| 9800100 | Analytical Support - PATH and ESA Biological Assessments | Path scientific report |
| 9303701 | Technical Assistance with Life Cycle Modeling | Path scientific report |
| 9007800 | Evaluate Predator Control and Provide Technical Support | Path scientific report |
| 9007700 | Northern Squawfish Management Program | Scientific report |

## Section 4. Objectives, tasks and schedules

### *Past accomplishments*

| Year | Accomplishment | Met biological objectives? |
|---|---|---|
| 1996 | Participated in initial stages of PATH planning and helped develop suite of hypotheses to test. | Yes |
| 1997 | Produced preliminary retrospective and prospective passage model runs for spring chinook. Proposed althernative forms for the life cycle model. Developed hypotheses about post-Bonneville "extra-mortality." | Yes |
| 1998 | Produced updated prospective and retrospective passage model runs for spring chinook. Participated in weight of evidence process by contributing reports. | Yes |
| | Calibrated CRiSP passage model with new survival data and produced preliminary retrospective and prospective runs. | |

### *Objectives and tasks*

| Obj 1,2,3 | Objective | Task a,b,c | Task |
|---|---|---|---|
| 1 | Complete Retrospective, Prospective and Sensitivity Analysis | a | Sensitivity analysis for spring/summer chinook. |
| | | b | Prospective analysis for fall chinook. |
| | | c | Mid-Columbia chinook analysis. |
| | | d | Steelhead analysis. |
| | | e | Response to SRP review. |
| | | | |
| | | | |
| 2 | Experimental Management | a | Evaluate experimental management alternatives of SRP and others. |
| | | b | Develop and evaluate experimental management scenarios involving transportation, predator control, and other actions. |

### *Objective schedules and costs*

| Obj # | Start date mm/yyyy | End date mm/yyyy | Measureable biological objective(s) | Milestone | FY2000 Cost % |
|---|---|---|---|---|---|
| 1 | 10/2000 | 9/2001 | | | 50.00% |
| 2 | 10/2000 | 9/2001 | | | 50.00% |
| | | | | | |
| | | | | | |
| | | | | **Total** | 100.00% |

**Schedule constraints**
Changes in PATH process may alter task timeline.

**Completion date**
2004

## Section 5. Budget

**FY99 project budget (BPA obligated):**

### *FY2000 budget by line item*

| Item | Note | % of total | FY2000 |
|---|---|---|---|
| Personnel | Direct salary | %53 | 158,950 |
| Fringe benefits | Standard UW benefit rates | %12 | 35,834 |
| Supplies, materials, non-expendable property | | %3 | 7,912 |
| Operations & maintenance | | %5 | 14,241 |
| Capital acquisitions or improvements (e.g. land, buildings, major equip.) | Office Lease | %6 | 16,657 |
| NEPA costs | | %0 | |
| Construction-related support | | %0 | |
| PIT tags | # of tags: | %0 | |
| Travel | | %2 | 7,500 |
| Indirect costs | | %19 | 58,354 |
| Subcontractor | | %0 | |
| Other | Tuition fees | %1 | 1,633 |
| **TOTAL BPA FY2000 BUDGET REQUEST** | | | $301,081 |

### *Cost sharing*

| Organization | Item or service provided | % total project cost (incl. BPA) | Amount ($) |
|---|---|---|---|
| | | %0 | |
| | | %0 | |
| | | %0 | |
| | | %0 | |
| | | **Total project cost (including BPA portion)** | $301,081 |

### *Outyear costs*

| | FY2001 | FY02 | FY03 | FY04 |
|---|---|---|---|---|
| **Total budget** | $302,000 | $302,000 | $302,000 | $302,000 |

## Section 6. References



| Watershed? | Reference |
|---|---|
| ☐ | |
| ☐ | Zabel, R.W., J.J. Anderson, and P.A. Shaw. 1998. A multiple reach model describing the migratory behavior of Snake River yearling chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences: 55:658-667. |
| ☐ | Zabel, R. and J.J. Anderson. 1997. A model of the travel time of migrating juvenile salmon, with an application to Snake River spring chinook salmon. North American Journal of Fisheries Management, 17:93-100. |
| ☐ | Anderson, J.J. (in press) Decadal climate cycles and declining Columbia River salmon. In Proceedings of the Sustainable Fisheries Conference, Victoria, B.C," ed. E. Knudsen. American Fisheries Society Special Publication no. 2x. Bethesda, MD. |
| ☐ | Anderson, J.J. A vitality based model relating stressors and environmental properties to organism survival. Accepted by Ecological Monographs, 1998. |
| ☐ | Anderson, J.J. 1996. Review of the influence of climate on salmon. In Plan for Analyzing and Testing Hypotheses (PATH): Final report on retrospective analyses for fiscal year 1996. Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C |
| ☐ | Anderson, J.J. , J. Hayes, P. Shaw and R. Zabel. 1996, Columbia river Salmon Passage Model CRiSP1.5: Theory, Calibration and Validation. School of Fisheries University of Washington. 220 pages. |
| ☐ | |
| ☐ | |
| ☐ | |
| ☐ | |

# PART II - NARRATIVE

## Section 7.  Abstract

The overall goal is to assist the region in developing the ability to identify and assess key alternative hypotheses relating to salmon stock recovery and rebuilding in the Columbia River ecosystem. This project will provide tools and analyses for the scientific ecosystem-based evaluation of the impacts of specific fish and wildlife program actions.

Specific objectives of this project are the development and use of statistical and mechanistic models of salmon life-cycle stages in various habitats: the mainstem (including passage of juveniles and adults), tributaries, estuary, and ocean. Both anthropogenic and environmental factors at each salmon life stage will be approached in a multi-faceted fashion involving qualitative descriptions, statistical data analyses, Bayesian maximum likelihood estimation techniques, and mechanistic models. Through these approaches, alternative hypotheses will be tested according to their mathematical rigor, the realism of their ecological mechanisms, and their ability to fit available data and data patterns.

An important outcome will be the development of tools to assist managers in assessing the strategic implications and validity of management decisions. The results will include reports and World Wide Web electronic documents that describe and evaluate modeling and analysis efforts..

## Section 8.  Project description

### a.	Technical and/or scientific background

**<u>Introduction:</u>**

The Plan for Analyzing and Testing Hypotheses (PATH) is a regional scientific process of formulating and testing hypotheses related to historical and future estimates of salmon survival.  It is intended to identify, address and (to the extent possible) resolve uncertainties in the fundamental biological issues surrounding recovery of endangered spring/summer chinook, fall chinook, and steelhead stocks in the Columbia River Basin.

The objectives of PATH are to:

1. determine the overall level of support for key alternative hypotheses from existing information, and propose other hypotheses and/or model improvements that are more consistent with these data;

2. assess the ability to distinguish among competing hypotheses from future information, and advise institutions on research, monitoring and adaptive management experiments that would maximize learning; and
3. advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance.

**Background:**

Columbia River salmon populations have been declining over the past century as a result of human use of the river and its resources including direct salmon harvesting, construction of dams, logging, water withdrawals for irrigation and municipal purposes, and other uses. The annual catch of Columbia and Snake River chinook exceeded 25 million pounds at the turn of a century. Today the population is approximately 0.5% of the historical abundance. In the 1950's as the hydrosystem was being developed, a series of mitigation efforts were implemented to maintain the runs. The original efforts involved installing adult bypass ladders on the mainstem dams and building hatcheries as mitigation for dams that permanently blocked access to spawning grounds in the upper reaches of the Columbia and Snake Rivers. Since completion of the Snake River hydrosystem in 1976, fish have been barged down river and the survival of the remaining fish passing in river has been improved with fish bypass screen, flow augmentation, and spill. The early efforts failed to recover the runs which forced the region to re-evaluate the effectiveness of the mitigation measures and to seek new approaches.

As a result, analytical modeling systems evolved in the early 1990's to address the needs of survival and recovery assessments for Snake River salmon stocks. State and tribal fishery managers, federal hydropower operators and NWPPC each maintained their own analytical modeling approaches. A regional Analytical Coordination Work Group (ANCOOR) was established during these first few years to help coordinate regional analyses between these groups. During FY 1994 and 1995, a scientific review panel (SRP) was funded to perform a critical review of the models. One report from that effort recommended that further model coordination efforts should be focused on hypothesis formulation and testing to resolve crucial differences in assumptions and data interpretation. NMFS concurred with this recommendation and in their 1995 Biological Opinion stated that "The BPA shall participate with NMFS in activities to coordinate the regional passage and life cycle models and to test the hypotheses underlying those models." Toward accomplishment of this goal, the PATH (Plan for Analyzing and Testing Hypotheses) process was developed and funded by BPA.

Participants in the PATH process include members of the following agencies: the Columbia Basin Fish and Wildlife Foundation, Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the Idaho Department of Fish & Game, the Columbia River Inter-Tribal Fish Commission, the National Marine Fisheries Service, the Bonneville Power Administration, the Army Corps of Engineers, the Fish and Wildlife Service, the Forest Service, and the Northwest Power Planning Council. This participation includes scientists under contract through the University of Washington and other private consulting firms. In addition, there are three non-affiliated academic scientists that work within the PATH process. Task and policy level oversight is provided through a five member PATH Planning Group and through interaction with the regional Implementation Team (IT). ESSA Technologies Consulting provides facilitation of the process and coordination of work products. A four member Scientific Review Panel (SRP) provides periodic review of PATH products and there is some occasional interaction with two members of the ISAB.

Currently, PATH has resulted in a retrospective (Marmorek et al. 1996) and prospective (Marmorek 1998) analysis on spring chinook, and a weight of evidence report in which four scientists reviewed and weighted the different hypotheses for spring chinook (Peters et al. 1998). In 1998-1999, the same procedure of retrospective/prospective/weighting steps are being performed for other listed stocks in the Snake River system including fall chinook and steelhead.

Although PATH has defined a number of hypotheses and have weighted them leading to probabilistic projections of the effectiveness of different recovery actions, there are still significant scientific disputes on the adequacy of the data used to analyze PATH and to conclude the analyses. In addition, there was a general agreement that the PATH results were difficult to understand and interpret by the public and decision makers. As a result, although the processes for spring chinook are mostly completed and now being applied to other species, concerns on the process still exist. This limitation is directing the PATH process to focus on experimental management issues in an attempt to add further concepts and data for future analysis and to better communicate results to the public.

In the context of experimental management, one of the PATH's goals will be integrating its analysis framework into the emerging Multi-Species Framework that is being implemented by the Northwest Power Planning Council. Simply put, PATH has focused on Snake River stocks individually. For the expanding ecosystem management of the Columbia/Snake River Basin, the quantitative data and information management tools of PATH need to become refined, focused on the ecosystem, and made more accessible to the public.

The region will have a continuing need to consider analytical results in decision making in a number of areas, including the development of specific recovery plans for listed salmon and steelhead stocks; the Endangered Species Act mandated Section 7 consultation process; and the development of rebuilding programs under the NWPPC Fish and Wildlife Program. The region would benefit in these areas from a coordinated and consistent approach to technical analyses supporting salmon rebuilding and recovery efforts. In recognition of the need, the NWPPC (Ibid., Sec. 7.3 ) has called for "....a process to provide for continuing review, coordination and development of analytical tools to assist decision making, facilitate program evaluation and identify critical uncertainties." The PATH process is intended to ensure that the region has the benefit of the use of best available scientific methods and information in the analyses supporting recovery/rebuilding efforts.

## b. Rationale and significance to Regional Programs

Both the Council for Fish and Wildlife Program (FWP) and the NMFS 1998 Supplemental Biological Opinion (SBO) indicate a need to develop and assess regional strategies to rebuild fish and wildlife populations through the use of credible and understandable analytical tools. SBO Section III-5 indicates the need to fund a regionally-coordinated analysis through a forum such as PATH and to fully coordinate with the ongoing PATH process to determine the effects of the proposed actions in the context of species level biological requirements over the life history of fish. NMFS will apply PATH analyses to make recommendations on the Snake River as well as the mid and lower Columbia River. FWP section 3.2F identified that computer models are essential to the framework by providing a means to align program measures with survival target rebuilding schedules. The tools developed should span legitimate scientific differences and approaches. The processes should not stifle these differences but rather promote understanding of their implications and integrate them into a unified approach.

## c. Relationships to other projects

The proposed work is an integral part of other PATH projects designed to develop a unified analysis system that is understandable and expresses different opinions and the implications of these differences.

The UW PATH project is an integral part of the PATH project. We participate in the development of models and analyses of results. Our group works actively with PATH groups listed in the table in Section 3. We provide passage model runs to the ESSA group and have developed critical hypothesis used in the PATH analyses and critiques of the documents.

## d. **Project history** (for ongoing projects)

The University of Washington Columbia Basin group initially developed a passage model for spring/summer and fall chinook in the Columbia River in 1991. The model was used as one of the modeling systems by the Snake River Recovery Team under the direction of Professor Bevan. An alternative modeling system was developed by the State and Tribal Agencies. Efforts to resolve the reasons for the differences in the model systems were addressed in a 16 week modeling process in 1993. It was soon realized that the issues of model comparisons were more complex and the data too uncertain to resolve the issues in a matter of months. As a result, PATH was established in 1995 to evaluate the competing points of view on the causes and solutions to the decline of salmon in the Snake and Columbia Basins. The UW team has been a major contributor to PATH from the beginning and has been responsible for developing and refining several elements of the passage and life cycle models over the three year period and its inception.

## Project Reports

Project numbers:
8910800
9700200

Summary of major results:
1. Development of the CRiSP models 1.1, 1.3, 1.4, 1.5, 1.6.
2. Development of an upstream model.
3. Development of a harvest model.
4. Development of the alpha life-cycle model.
5. Development of the climate hypothesis.
6. Turbine hypothesis for retrospective analysis.
7. Evaluation and clarification of differences between modeling systems.
8. Contribution to PATH reports in 1995, 1996 1997 and 1998.
9. Reviewing Chapter 12 of PATH 1996 and Anderson (1999) climate information as it contributes to stock decline.
10. Developing and calibrating fish travel time equations for spring/summer and fall chinook and steelhead and publishing the models reviewed journals (Zabel et al. 1997, Zabel et al. 1998).
11. Maintaining a World Wide Web page of PATH information.
12. Evaluating harvest strategies on stock recovery.
13. Developing a harvest model based on the chinook technical team management model.
14. Providing critiques of PATH documents.

### e. Proposal objectives

PATH is an interactive process in which the objectives of the PATH group involving scientists representing state, tribal, and federal agencies are adjusted according to the results of past analyses and future needs as directed by new research findings and coordinated agencies including NPPC and NMFS. By the end of 1999, the goal is to have an integrated analysis system that has considered retrospective and prospective analysis of spring and fall chinook and steelhead in the Snake River system.

The 1999 objectives of the PATH effort will be relevant mostly for post analysis in the 2000 decisions and into ecosystem approaches through a Multi-species Framework. These include nine objectives:

1. Define the management decisions that serve to focus analytical activities.

2. Bound the anadromous salmonid ecosystem components under consideration.

3. Explicitly define alternative hypotheses and implications for the functioning of ecosystem components, in terms of the distribution of survival over the

populations' life-cycle, and the life stage and population responses to management actions under different natural conditions.

4. Compile and analyze information to assess the level of support for alternative hypotheses (component, composite, and aggregate hypotheses).

5. Propose other hypotheses and/or model improvements supported by the weight of evidence of these analyses.

6. Provide guidance to the development of regional programs that would stabilize, ensure persistence and eventually restore depressed salmon stocks to self-sustaining levels.

7. Improve existing models and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks (i.e. assess conservation risk) under alternative management scenarios.

8. Provide guidance to managers on the strategic implications of hypothesis tests for key management decisions, and for the design of research, monitoring and adaptive management experiments that maximize the rate of learning and clarity of decisions.

9. Provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program (i.e. iterative evaluation of results of research, monitoring, and adaptive management experiments; assess implications of alternative hypotheses on subsequent actions).

The CBR objectives will contribute to PATH post analysis 1999 decisions. Our objectives focus on areas where we have developed expertise relevant to PATH and regional salmon issues. Since the specific directions and needs for the quantitative analysis have not been identified at this time, our goals will be modified by the needs of the post 1999 decisions. Our priorities are to accommodate goals identified in the NMFS Biological Opinion (1995, 1998) and NPPC FWP.

Objective 1. Complete Retrospective, Prospective and Sensitivity Analyses

Elements of the FY99 work plan are scheduled for completion in October 1999. If these are not completed on schedule, the first objective will be to complete these tasks. The following tasks are identified for completion and are listed in the PATH 1998 Final Report draft. Our focus in these tasks are identified below.

a. Additional sensitivity analysis for response of spring/summer chinook recovery probabilities to the actions such as A1, A2, A3, A6 and B1.

b. Sensitivity to other actions includes: a) impact of drawdown scenarios to conversion ratios of the up and downstream migrating fish; and b) impact of recovery probabilities if the spawner recruitment relationship has a nonlinear density dependence.

c. Further prospective analysis for fall chinook: Fall chinook analyses will be completed and sensitivity analyses will be developed to identify the important factors including downstream passage and upstream conversion rates. Sensitivity to assumptions not yet considered but to be completed includes: a) impact of drawdown scenarios to conversion ratios of the up and down stream migrating fish; and b) impact of recovery probabilities if the spawner recruitment relationship has a nonlinear density dependence.

d. Mid-Columbia chinook analysis: Mid-Columbia analyses will involve a retrospective and prospective analysis of the impacts of anthropogenic and environmental factors on fish survival. A sensitivity analysis will be conducted to identify the important factors including downstream passage and upstream conversion rates. Sensitivity to assumptions not yet considered will also be completed including: a) impact of drawdown on conversion ratios of the up and downstream migrating fish, and b) impact of recovery probabilities if the with spawner recruitment relationship has a nonlinear density dependence.

e. Steelhead analysis: Steelhead analysis is limited because of the complexity of the steelhead life cycle that has various residences in fresh water and the ocean. Analysis will focus on survival of juvenile and adult (kelts) passage through the hydrosystem. A sensitivity analysis will be conducted to identify the important factors including downstream passage and upstream conversion rates.

f. Response to SRP review: A response to the SRP weighting of results from the 1999 analysis will be developed. This will include analysis response to SRP review of steelhead, fall chinook and spring/summer chinook. In the evaluation we will determine if an alternative weighting scheme is justified by our analysis and then weight the action alternatives according to these evaluations. The review of the SRP weighting and any alternative weightings will be provided to the region either through PATH or through a forum yet to be determined.

g. All tasks will documented for inclusion in PATH.

Objective 2. Experimental Management

In the post 1999 decision period, it is expected that work will be required to identify experimental management protocols that can reduce uncertainty in the analysis identified by PATH and should increase the probability of stock recovery. The weight of evidence report (SRP 1998) suggested that an experimental management approach involves major modification of the existing hydrosystem including breaching dams, drawing down lower

Columbia reservoirs and restricting hatchery output. A number of management scheme alternatives were not mentioned by the SRP that may be requested by regional parties. These include modification of the transportation program to improve fish conditions and release in the estuary, control of predators in the estuary, and improvement of fish survival prior to entrance into the hydrosystem. These second alternatives would involve modification of the existing system but without major changes.

a. Using the evolving adaptive management approach in PATH through FY 1999, we will evaluate the proposed experimental management alternatives put forward by the SRP and others. These will be evaluated on their potential for recovery as identified through the sensitivity analysis and weighting of hypotheses.

b. Using the PATH developed management framework, we will outline experimental management scenarios that involve diverse alternatives such as improving transportation to spread the risk of mortality during estuary entrance, expanding predator control in the estuary, tributary fertilization, and other actions.

## f. Methods

Through the PATH process, an evolving adaptive management system involving data analysis and modeling has been developed. Modeling is a stepped process: a) development of analytical forms for the models of different life stages including egg-fry development, juvenile survival, smolt survival, ocean survival, upstream migration and spawning; b) calibration, where possible, of different life stage survivals; c) fitting the combined life-cycle model to spawner-recruitment data in a retrospective analysis; and d) hypothesizing the effect of actions on mortality elements in the life cycle of the fish.

Under the Objective 1, we will use a suite of model analyses and tools. To evaluate the effects of the hydrosystem on fish passage, we will use the CRiSP 1.6 model or a later version. This model was developed from fish passage dynamics (Zabel et al. 1997, 1998) and mortality equations (Anderson et al. 1997, Anderson 1999, Anderson et al. 1999) and calibrated with the most up-to-date PIT tag survival information, dam passage dynamics, gas bubble disease and other factors that affect fish stress and survival. The calibration uses a multiparameter minimization in which several objective functions are simultaneously fit using Marquart-type search algorithms. The CRiSP model is described in various documents including Anderson et al. (1997), and PATH annual and interim reports compiled under Path-Facilitation, Technical Assistance & Peer Review (Project 9600600).

To assess the impacts of cumulative stress on juvenile hydrosystem passage, a survival model based on time-cumulative and time-independent mortality processes will be incorporated into the passage model and calibrated with the survival data. The model is based on the concept of vitality: a stochastic rate process proportional to the effects of stressors. In the case of fish, this includes gas bubble disease, temperature and dam passage (Anderson, accepted by Ecological Monographs). This model provides a realistic, biologically based method of characterizing the delayed impacts of stress in hydrosystem passage. The algorithm is being incorporated into the CRiSP passage model in FY1999 and will be available for analysis of smolt passage issues in FY2000.

To address the impacts of drawdown on juvenile survival, we will use two model approaches: 1) the CRiSP passage model and 2) an individual based model (IBM) that characterizes movement and interaction of smolts and predators in the reservoir environment in a drawdown configuration. The IBM is based on the SWARM modeling system developed at the Santa Fe Institute in 1990s. The specific model is an adaptation of the California Individual-Based Fish Simulation System developed by Lang, Railsback & Associates, the U.S. Forest Service, and Humbold State University. This modeling system uses information on the topography and hydraulics of a reservoir as determined by models developed by the Battelle Pacific Northwest Laboratory plus information on predator bioenergetics, behavior and distributions being determined as part of the studies on Evaluate Predator Control and Provide Technical Support (Project 9007800) and the Northern Squawfish Management Program (Project 9007700). This model will allow investigation of how the effective predator habitat changes with drawdown and how this in turn changes the predator-prey encounter rate.

A central assumption of the PATH analysis is that the stock productivity response is log-linear with respect to spawner density. In this framework the productivity increases with decreasing stock levels. Although the assumption is supportable for populations near their carrying capacity, under the current low stock levels in the Snake and Columbia River system there is no distinct relationship (See Chapter 3, Contrast of Stock-Recruitment Patterns of Snake and Columbia River Spring and Summer Chinook, in PATH final Report on Retrospective Analyses for 1996). In many of the Snake River stocks, the log-linear relationship breaks down and the data exhibits a large amount of variability. This pattern suggests the possibility of density-neutral productivity at the low current levels of stocks in the system. The form of productivity with low stock levels may also be influenced by the lack of stream carcass fertilization as well as short and long period weather cycles that perturb the deterministic dynamics of the spawner-recruitment relationship. These features are missing from the Ricker spawner-recruit curve that was used in PATH. We are concerned that PATH conclusions that imply a large mortality factor attributed to the hydrosystem or an unspecified extra mortality process may in fact be an artifact of the Ricker curve. To address these issues, a non-liner density dependent model, being developed in 1999, will be applied to the PATH models to determine the significance of varying the assumptions on density dependence on fish recovery actions.

Although the above model systems meet the needs of detailed analyses of fish recovery actions, there is a need to translate the results of the models into simplified terms that can be understood by the public. To address this need, proposed recovery actions will also be illustrated through a simple model that describes life-cycle survival as a multiplicity series of simple life stage survival rates. A need for a simple life cycle model was also noted by the Scientific Review Pannel. They suggested that the model follow along the lines of one proposed by Anderson in a Nov. 1997 e-mail to PATH. This simplified model will be developed in FY1999 and applied to recovery proposals in FY2000.

In Objective 2 we will assist in the design and evaluation of experimental management proposals using the SWARM IBM model, the CRiSP passage model, a non-linear spawner-recruitment model and a simple life-cycle model as noted above. In addition specific analysis will be conducted using a quantitative focus to address specific issues that do not fit into the existing model systems.

### g. Facilities and equipment

The PATH project used existing facilities and equipment. The budget does not include purchase of new equipment.

### h. Budget

Salary and benefits rates are computed based on several categories of staff involved.

Supplies include software and miscellaneous hardware computer supplies.

Operations and Maintenance include local & long distance phone, publications, software licenses & support, internet cost, equipment insurance & repairs, postage, freight, and photocopy.

Travel is projected for meetings in Portland and other locations where PATH meetings will be held. A trip to present results of the project at national meeting is included.

Indirect Costs are computed based on Modified Total Direct Costs times 26%. This off-campus rate is provided by the UW and is anticipated to remain unchanged until year 2002.

## Section 9. Key personnel

# Curriculum Vitae

**James J. Anderson**
**Columbia Basin Research, University of Washington**
**1325 – 4th Ave., Suite 1820, Seattle, WA 98101**
**Phone: 206-543-4772; Fax: 206-616-7452**
**Email: jim@fish.washington.edu**

## Associate Professor (WOT)

Fisheries Research Institute and Center for Quantitative Science in Forestry, Fisheries and Wildlife
College of Ocean and Fisheries Sciences

## Teaching Activities:

Graduate course in modeling organism dynamics (QSCI 551)
Graduate course in Ecosystem models (QSCI 550)

Students Receiving Degrees: Three in M.S. Fisheries, Two in M.S. Quantitative Ecology & Resource Management, and Two in Ph.D. Quantitative Ecology & Resource Management.

## Current Research Projects:

Bonneville Power Administration (Funding level: $6+ million): Developing computer models for management of Columbia River hydroelectric and fisheries agencies.

U.S. Army Corps of Engineers (Funding level: $1+ million): Developing analysis and computer models for the impact of gas bubble disease on migrating salmon.

National Marine Fisheries Service (Funding level: over $500K):

1) Studying mortality processes of juvenile salmon in tributaries
2) Developing a multi-species multi-regional salmon harvest model

## Honors and Awards:

1) Research Faculty Fellowship, College of Ocean and Fishery Sciences 1985, 1989.
2) Special Recognition for participation in the U. S. Fish and Wildlife Service Fish Passageways and Division Structures course in 1990.
3) Nomination for Computerworld Smithsonian Awards in programming for the CRiSP computer model College of Ocean and Fishery Sciences Distinguished Research Award, 1996.

**Professional Activities:** Consulting; Expert Testimony on Fish Migration and Dam Passage; Guest Speaker

## Selected recent publications from over 45 publications and reports include:

Anderson, J.J. 1998 (in press). Decadal Climate and Declining Columbia River Salmon. Proceedings of the sustainable Fisheries Conference, Victoria B.C., Canada. Eric Knudsen, Editor. American Fisheries Society special publication no. 2x. Bethesda, MD.

Anderson, J.J. A vitality based model relating stressors and environmental properties to organism survival. Accepted by to Ecological Monographs in 1998.

Helu, S.L., J.J. Anderson, D.B. Sampson. 1998. An individual-based boat fishery model can generate fishery stability. Natural Resource Modeling. (In press)

Zabel, R.W., J.J. Anderson, and P.A. Shaw. 1998. A multiple reach model describing the migratory behavior of Snake River yearling chinook salmon (Oncorhynchus tshawystscha). Canadian Journal of Fisheries and Aquatic Sciences: 55:658-667.

**Curriculum Vitae**
**Richard William Zabel**
**Columbia Basin Research**
**Phone: 206-685-1132**

## Education

B.S. (with honors and distinction), in Botany, The University of Michigan, Ann Arbor, 1983.
M.S., in Plant Biology, The University of Michigan, Ann Arbor, 1988.
Ph.D., in Quantitative Ecology and Resource Management, The University of Washington, Seattle, 1994.

## Recent Employment and Research experience

July 1997 - present: Research Consultant, Columbia Basin Research, School of Fisheries, University of Washington. Research on salmon survival issues including participation in PATH process.

January 1995 - June 1997: Post Doctoral Research Associate, School of Fisheries, University of Washington. Work with Professor James Anderson developing and calibrating models of salmonid migration.

March 1994 - December 1994: Research Consultant, The Center for Quantitative Science, University of Washington.

## Responsibilities

Develop models of juvenile and adult migration in the Columbia River system. Perform data analysis to calibrate models for predictive purposes. Participate in regional forums that analyze salmon survival issues and make recommendations for measures to recover endangered stocks. Write papers for publication in scientific publications.

## Publications in refereed journals, conference proceedings, and dissertation


Zabel, R.W. and J.J. Anderson. 1997. A model of the travel time of migrating juvenile salmon, with an application to Snake River spring chinook salmon. North American Journal of Fisheries Management, 17:93-100.

Zabel, R.W., J.J. Anderson, and P.A. Shaw. 1998. A multiple reach model describing the migratory behavior of Snake River yearling chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences 55: 658-667.

Zabel, R.W., J.J. Anderson, and J.A. Hayes. 1998. Calibration and validation of the Columbia River Salmon Passage (CRiSP) Model. In E. L. Brannon and W.C. Kinsel Editors, Proceedings of the Columbia River Anadromous Salmonid Rehabilitation and Passage Symposium, June5-7, 1995. Aquaculture Research Institute, University of Idaho.

Zabel, R. W. 1994. Spatial and Temporal Models of Migrating Juvenile Salmon with Applications. Ph.D. dissertation, University of Washington, Seattle.

# Curriculum Vitae

**James Grant Norris**
**Columbia Basin Research, University of Washington**
**Phone: 360-385-4486**
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## Education

1989 PhD Fisheries University of Washington, Seattle, WA
1972 MS Fisheries University of Alaska, Fairbanks, AK
1968 BS Mathematics University of California, Davis, CA

## Work Experience

AUG 1992 - PRESENT: Fishery Research Consultant, Columbia Basin Research,University of Washington, Seattle, WA. Coordinate development of mathematical harvest models for Pacific salmon stocks, with emphasis on Columbia River stocks. Research includes estimating ocean harvest rates and residence proportions from coded-wire-tag data. Projects are funded by Bonneville Power Administration and the National Marine Fisheries Service.

APR 1989 - PRESENT: Marine Resource Consultants, Port Townsend, WA.
Provided scientific analysis of various harvest issues to fishery mangement agencies. Developed underwater videographic mapping system for nearshore marine habitats. The mapping system has been applied throughout Puget Sound and Willapa Bay and was awarded Honorable Mention in the 1997 Applications Contest sponsored by GPS World Magazine.

SEP 1986 - MAR 1989: Graduate Research, School of Fisheries, University of Washington. Analyzed harvesting strategies for sablefish fishery off the coasts of Washington, Oregon, and California. Included linear programming analysis of multi-species/multi-gear fisheries, yield per recruit analysis (with reproductive considerations) for sablefish stocks, and development of methods for incorporating political objectives in fishery models.

**National Committees and Panels**: Member of the 1997 Environmental Protection Agency (EPA) Peer Review Panel for the Experimental Program to Stimulate Competitive Research (EPSCoR). Reviewed 37 research proposals for scientific merit in a national competition for EPA research funds.

## Selected Publications

Norris, J. G. (in press) Defining equivalent harvest rate reduction policies for endangered Pacific salmon stocks. Presented at Towards Sustainable Fisheries: Balancing Conservation and Use of Salmon and Steelhead in the Pacific Northwest. Victoria, BC. April, 1996. Published as a special publication of the American Fisheries Society.

Norris, J. G. 1991. Summary of chinook salmon bycatches in the BSAI and GOA groundfish fisheries: Jan. 1, 1991 - Nov. 10, 1991. Submitted to the North Pacific Fishery Management Council, Anchorage, AK.

Norris, J. G. 1991. Further perspectives on yield per recruit analysis and biological reference points. Can. J. Fish. Aquat. Sci. 48: 2533-2542.

# W. Nicholas Beer

**Columbia Basin Research, Box 358218, University of Washington,**
**Seattle, WA 98195, Phone: (206) 221-3708 nick@cqs.washington.edu**

## *Education:*

M.S. 1996. Quantitative Ecology and Resource Management, University of Washington.

1990. Harvard University, Graduate School of Education. Visiting scholar on fellowship from Outward Bound USA.

B.A. 1983. Environmental Studies, University of Vermont.

## *Current Employment:*

Research Consultant Columbia Basin Research,
University of Washington, Box 358218, Seattle, WA 98195

Responsible for juvenile salmon growth analysis. Writing and publication of research findings. GIS data management and analysis.

## *Recent Employment:*

Research Assistant / System Analyst/Programmer I/II 9/92-3/97
Center for Quantitative Science, University of Washington, Box 358218, Seattle, WA 98195

Technical Writer / Software tester, Alki Software 9/ 91-5/92
300 Queen Anne Ave. N., Suite 410, Seattle, WA 98109

## *Expertise:*

Statistical and mathematical modelling skills including use and application of mechanistic and stochastic models, 5 years experience in GIS analysis and AML programming using ARC-INFO including spatial/analytic problem solving and data conversion management; UNIX, C, S+, Perl, AML and JavaScript programming; advanced training in ecological dynamics. Technical writing and editing in academia and private sector.

## *Publications:*

Beer, W. N. (in press) Comparison of mechanistic and empirical methods for modeling embryo and alevin development in chinook salmon. Progressive Fish Culturist.

Beer, W. N. and J. J. Anderson, 1997. Modelling the growth of salmonid embryos, Journal of Theoretical Biology.

Beer, W. N., 1996. A growth model for larval salmon with application to field and laboratory observations of chinook salmon. Master’s thesis, University of Washington, Seattle, WA.

Wissmar, R., and W. N. Beer, 1994. Distribution of fish and stream habitats and influences of watershed conditions, Beckler River, Washington. Fisheries Research Institute, University of Washington, 98195.

**David H. Salinger**
**Columbia Basin Research, University of Washington**
**Seattle, WA 98195**
**Phone: (206) 616-7449; Email: salinger@cqs.washington.edu**

## *Education:*

Ph.D. 1997. Applied Mathematics, University of Washington.
Specializations: Stochastic and deterministic optimization, mathematical modeling.
Dissertation title: "A Splitting Algorithm for Multistage Stochastic Programming with Application to Hydropower Scheduling." Work included algorithm development, implementation for a large scale (200,000 variable) test problem and theoretical results on optimality and convergence.
Pertinent course-work: Math Ecology(3), Numerical Analysis(3), Optimization(6).

M.A. 1987. Mathematics, Pennsylvania State University
Specializations: Applied Mathematics, Geophysics, Fluid Flow.

B.A. 1984. Mathematics/Geology (dual major), State University of New York at Oneonta.

## *Current Employment:*

Research Consultant Columbia Basin Research, University of Washington, Seattle.
Responsibilities: Have primary responsibility for development and coding of optimization routines for calibration of salmon passage model to data. Provide mathematical support for modeling projects and in the development of methodologies.

## *Recent Employment:*

Research Assistant / Teaching Assistant 9/90-6/97
Dept. of Applied Mathematics, University of Washington, Seattle, WA 98195.

## *Expertise:*

Optimization techniques including methods for calibration of models to data as well as methods for large scale stochastic and deterministic optimization; mathematical modeling including ecological and hydrosystem modeling; Numerical analysis and mathematical problem solving techniques; Unix, C programming.

## *Publications:*

Salinger, D. H. and Rockafellar, R.T. (submitted) Dynamic Splitting: An Algorithm for Deterministic and Stochastic Multiperiod Optimization. SIAM J. Optimization.

Salinger, D. H. 1997 A Splitting Algorithm for Multistage Stochastic Programming with Application to Hydropower Scheduling. Doctoral thesis, University of Washington, Seattle, WA.

## Section 10. Information/technology transfer

Result from the UW PATH work will be distributed through four forms:

1. Communications about PATH issues will be submitted to relevant participants in PATH via e-mail.

2. PATH documents will be placed on the PATH webpage maintained at the Columbia Basin Web Server. This service is provided to all PATH participants and the page currently holds materials from two years of PATH work. Documents can be read on-line as HTML documents, or download as PDF, Word or Excel files.

3. Documents will be transmitted to ESSA for inclusion in PATH reports.

4. Selected documents will be submitted to reviewed journals.

## Congratulations!